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Canadian Association of Radiologists Journal 61 (2010) 74–79

CANADIAN ASSOCIATION OF RADIOLOGISTS JOURNAL

www.carjonline.org

Musculoskeletal Radiology / Radiologie musculo-squelettique

Puck to Pubalgia: Imaging of Groin Pain in Professional Hockey Players

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Key Words: Athletic pubalgia; Sportman's hernia; Sports hernia; Gilmore's groin; Groin disruption; Groin injury; Hockey; MRI; Athletic injuries; Groin pain; Secondary cleft sign; Adductor dysfunction; Osteitis pubis; Prehernia complex

Hockey is one of the fastest and most aggressive team sports, with great potential for injury. Groin injuries are common (5%–7% of all ice hockey injuries), can occur without contact, and account for a game loss of 25 player games per team per year in the National Hockey League (NHL) [1]. Injury data from the NHL revealed that 13–20 per 100 players per year sustained groin injuries [2]. These injuries are also seen in the amateur athlete, although they are often more severe in professional hockey players because of increased stresses and continued play despite injury.

The groin is a complex anatomical region where 3 major body areas (abdomen, pelvis, and lower limbs) meet. Groin pain in athletes has multiple etiologies that are not often clinically apparent, some of which are classified under the term ''athletic pubalgia'' [3]. Athletic pubalgia is a clinical syndrome that may take on numerous forms and variations but primarily includes refractory unilateral or bilateral groin pain exacerbated by activity [4]. Chronic groin pain in athletes may also be of hip joint etiology, particularly secondary to femoral-acetabular impingement seen in this age group. Without proper diagnosis and treatment, these injuries may become chronic and even career threatening.

The ability of magnetic resonance imaging (MRI) to depict anatomy and soft-tissue characteristics has proven useful in the evaluation of patients with groin pain [5,6]. It can be helpful in detecting the location of injury as well as delineating among muscular, tendinous, periosteal bony, and chondral injuries. We describe the magnetic resonance (MR) features of some of the most common causes of groin pain in NHL players observed at our institution.

Current Challenges of Athletic Pubalgia

Athletic pubalgia has been a diagnostic and therapeutic conundrum for years. The diagnosis of groin pain in athletes is difficult because physical examination findings are neither sensitive nor specific and because 27%–90% of patients have multiple coexistent injuries [7]. Causes of groin pain include numerous specific injuries to muscular, tendinous, osseous, and even visceral structures. On physical examination, patients often present with point tenderness at or near the pubic symphysis, pain on ipsilateral hip adduction, and no palpable hernia.

Historically, there has not been a single diagnostic imaging examination to evaluate all of the structures of the groin. For instance, although arthrography guided by fluoroscopy or multidetector computed tomography (MDCT) of the pubic symphysis may be useful in diagnosing articular lesions that involve the pubic symphysis, these modalities fail in the setting of tendinous injury, abdominal muscular pathology, and lesions distant from the symphysis [4]. Focused ultrasound, however, is a useful tool for tendinopathies but is inferior in imaging internal derangements of the hip and articular pathologies at the symphysis [4]. Hip MR arthrography is the examination of choice for demonstrating the hip labral and acetabular chondral abnormalities seen in cam or pincer femoral-acetabular impingement [6].

Without a definitive pathological diagnosis, no best standard of care exists, and patients may suffer unnecessarily. In the authors' experience, MRI is the single best test to combine the sensitivity for evaluating not only the osseous

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0846-5371/$ - see front matter
doi:10.1016/j.carj.2009.10.010

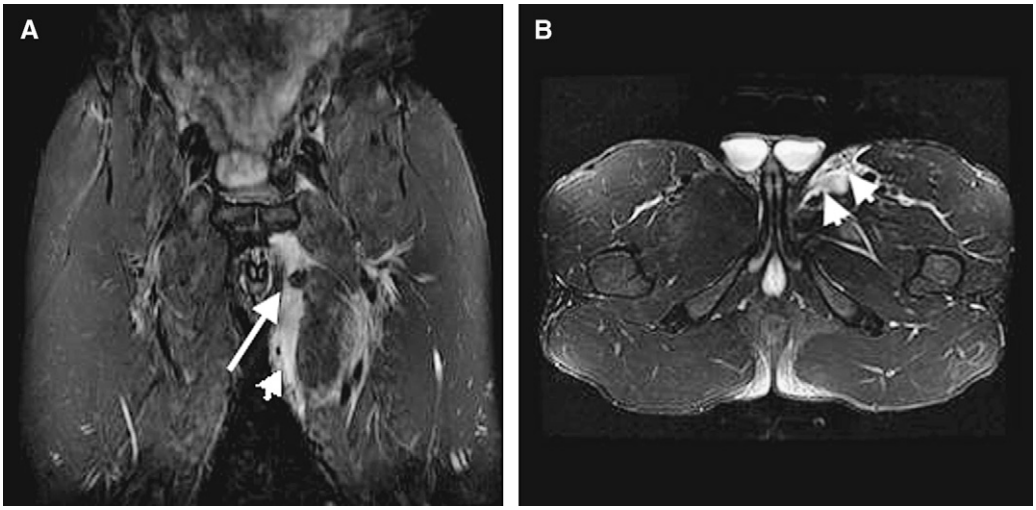

Figure 1. (A, B) Coronal and axial fast spin echo short T1 inversion recovery (FSE STIR), demonstrating complete tendinous avulsion of the left adductor longus from the pubis with 2–3 cm of retraction present (arrow). Extensive regional soft tissue oedema is present (arrowhead).

stress response and articular lesions but also the specificity for myotendinous lesions and acetabular labrum tears, the latter when MR arthrography is used. With better evaluation of the anatomy, a more appropriate referral can be made to a general surgeon, orthopaedic surgeon, or sports medicine physician.

Adductor Muscle Injury

Muscles are strained or torn when some or all of the fibers fail to meet the mechanical stresses placed upon them. Muscle strains are classified into 3 grades: a grade I strain is a tear of a small number of muscle fibers and causes localized pain but no loss of strength; a grade II strain implies a tear of a significant number of muscle fibers, with associated pain, swelling, and decreased range of motion; and a grade III strain is a complete tear of the muscle [8]. A muscle is most likely to tear during sudden acceleration or deceleration and thus is a common precipitant in hockey injuries.

The adductor muscles function in adduction, external rotation, and anteversion of the hip. Repetitive motions, such as ipsilateral hip extension and contralateral torso rotation seen in a slap shot [9], often predispose these muscles to injury. Adductor muscle injury is often described as a muscular groin pain exacerbated with skating and shooting, and is one of the most common injuries noted on MRI in patients presenting with groin injury [10].

On MRI (Figures 1, 2), adductor injury is best demonstrated by hyperintensity on fat-saturated fluid-sensitive sequences within the tendon and/or muscle belly secondary to disrupted fibers. Bony oedema around the pubic symphysis or fractures or avulsions can also be seen. Although a secondary cleft sign (a continuation between a physiological central fluid-filled cleft and a pathological secondary cleft within the symphyseal fibrocartilage seen

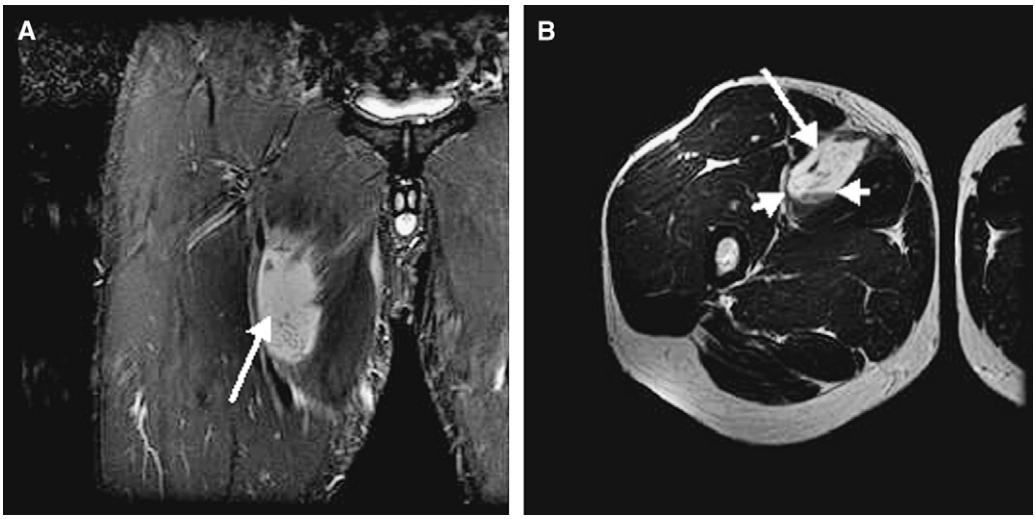

Figure 2. (A, B) Coronal and axial fast spin echo short T1 inversion recovery (FSE STIR), demonstrating an oblong area of increased signal within the muscle belly of the adductor longus muscle (arrow), which contains a fluid-fluid level (arrowhead) indicative of a partial tear of the muscle with resultant hematoma.

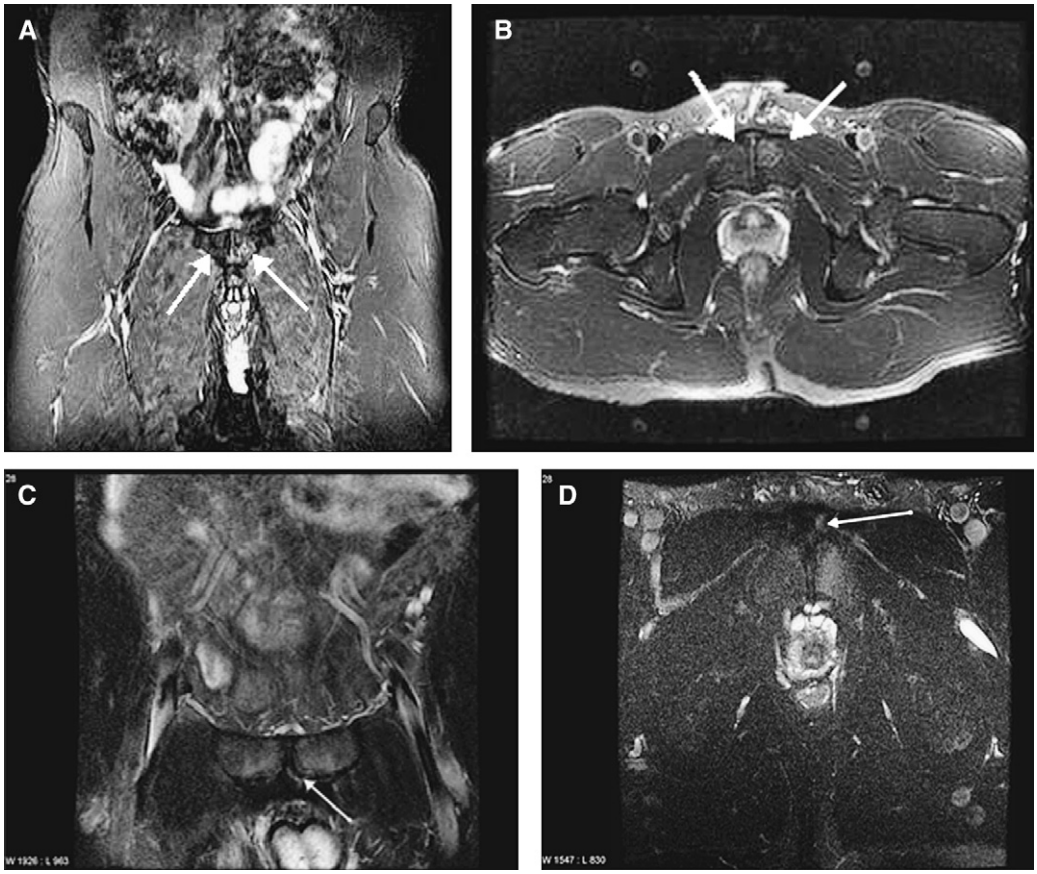

Figure 3. (A, B) Coronal short T1 inversion recovery (STIR) and axial T2 fat-saturated (FS), demonstrating increased perisymphyeal hyperintensity (arrows) consistent with osteitis pubis. Degenerative changes (joint irregularity) are also noted. (C, D) Coronal and (C) axial STIR images, demonstrating a modest amount of bone oedema in the left symphysis pubis, with virtually none seen on the right. There is a linear region of high T2 immediately adjacent (secondary cleft sign, arrow), but no discrete adductor myotendinous abnormality or rectus sheath abnormality is seen. No abnormal muscle oedema is seen in the area.

on short T1 inversion recovery [STIR] coronal images) is also a frequent finding among patients, it is unclear whether this represents a breach in the rectus abdominis tendon insertion extending into the adductor tendon origin or a result of chronic abnormal stress in the pelvic ring [11].

Osteitis Pubis

The symphysis pubis acts to dissipate and cushion impaction forces imposed on the anterior pelvis [12]. Osteitis pubis represents a chronic injury secondary to skating, contact with other players, and a rapid change in direction that results in abnormal shearing and/or rotational forces across the symphysis pubis. It is often associated with an adductor injury and rectus abdominus strains. It presents as localized pain over the symphysis that radiates to the medial thigh, lower abdomen, and perineum.

On MRI, acute findings of osteitis pubis include relatively symmetric perisymphyseal hyperintensity on fluid-sensitive sequences, which reflects diffuse subchondral bone marrow oedema (Figure 3). Chronic changes include bony irregularity, subchondral sclerosis, subchondral resorption, and osteophytosis. It is hypothesized that prolonged traction by hip adductors, gracilis, and possibly the conjoined tendon on the pubic rami, and by the common aponeurosis anterior to this joint, results in loss of morphologic features and thus chronic maceration of the fibrocartilaginous disk. In turn, it is hypothesized that this may also lead to formation of a secondary cleft that communicates with a physiological central cleft. This communication is easily identified as a central focus of high signal intensity at T2-weighted and fat-suppressed STIR imaging [11]. Because this secondary cleft sign can be identified in the absence of recognized features of osteitis pubis, it should be specifically looked for on coronal STIR images [11]. Moreover, signal intensity abnormalities in the marrow of the pubic bone have also been suggestive of osteitis pubis [11].

Prehernia Complex

The inguinal canal is a diagonal passage formed by the aponeuroses of the 3 flat abdominal muscles and contains the spermatic cord (male), round ligament (female), and ilioinguinal nerve. The prehernia complex (sportsman's hernia, Gilmour's groin) represents injury to the tissue that surrounds the inguinal canal (with no actual bowel herniation occurring), secondary to strain or sudden increases in intra-abdominal

Figure 4. Axial fast spin echo (FSE) T2 fat saturated (FS), demonstrating considerable oedema (arrow) within the anterior soft tissues in the region of the superficial inguinal ring and abdominal-wall aponeurosis, which suggests a prehernia complex.

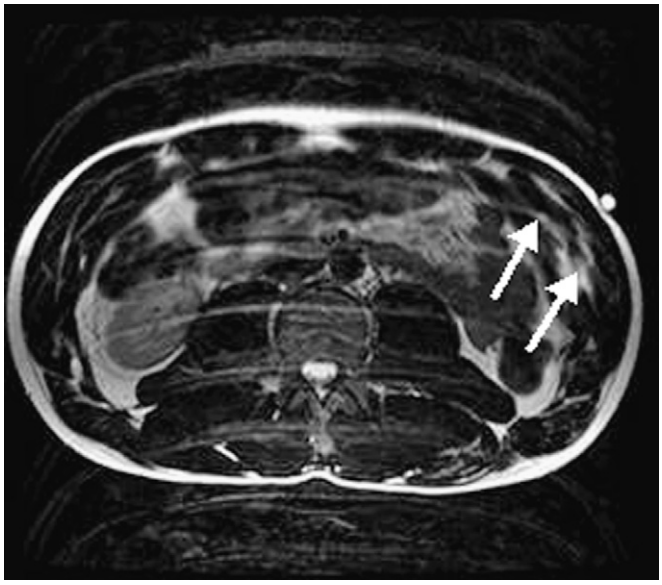

Figure 5. Axial T2, demonstrating a 2.5-cm, full-thickness tear of the left anterolateral abdominal wall (arrow) that involves primarily the internal oblique muscle but also the transverse (or transversus) abdominis muscle.

pressure. The existence of this injury is debated, because some radiologists consider it an early inguinal hernia, whereas others believe it to represent small ruptures in the muscles and tendons around the inguinal canal [13,14]. Clinically, it is described as chronic groin pain that is often worse in the evening and is exacerbated by activities that increase intra-abdominal pressure. On MRI, there is bulging or small tears of the inguinal wall seen as hyperintensity on fluid-weighted sequences around the inguinal canal.

Abdominal Muscle Tears

Abdominal muscles support and move the trunk and aid in respiration. Noncontact injury usually involves tears secondary to sudden violent contraction of a stretched muscle during twisting motions of the trunk [15]. In hockey, this often occurs during a slap shot when significant force is transmitted to the abdominal wall. This results in small tears within the abdominal-wall aponeurosis, which can damage neurovascular bundles that contain branches of the ilioinguinal or iliohypogastric nerves [9,13]. It presents as chronic pain in the iliac fossa region and tenderness in the abdominal wall where these nerves pierce the musculature near the anterior superior iliac spine [13].

On MRI (Figures 4, 5), the appearance can vary and may include hyperintensity on fluid-sensitive sequences in and/or between muscle and tendon in strains, focal muscles defects in partial tears, and full-thickness tears, with complete muscle disruption and increased signal in the gap between retracted segments. The tendinous injury often occurs at a reproducible location at the insertional fibers of the rectus abdominis tendon on the anteroinferior aspect of the pubic bone, approximately 1 cm lateral to the symphysis [10]. When the injury involves both the rectus abdominis and adductor tendons, the injury is often confluent on MRI and extends from the insertional rectus abdominis fibers into the abutting proximal fibers of the adductor longus and brevis tendons at the anteroinferior pubis lateral to the symphysis [10]. This injury pattern is often associated with asymmetric and predominantly anterior bone marrow and periosteal oedema in the adjacent pubis, which suggests a bony reactive process related to tendon avulsion. In one study, by Zoga et al [10], it was determined that these findings are highly sensitive and specific for detecting rectus abdominis injuries at the pubic attachment. It is important to note that true hernias are exceedingly rare, and, thus, imaging reports should use terms more descriptive of the true disorders, such as rectus abdominis tendinosis or tear.

Hip Abnormalities

If a patient is not found to have any of the aforementioned findings but still has groin pain, it is important to rule out referred pain by imaging the ipsilateral hip joint. Most commonly, MRI (Figure 6) findings show an internal derangement of the hip joint in the form of a labral tear, arthropathy, or femoroacetabular impingement. The acetabular labrum is a fibrocartilaginous structure that enlarges the overall surface area for articulation with the femoral head. Labral tears in hockey players most commonly occur secondary to trauma or repeated twisting motions of the hip. These injuries initiate or accelerate degenerative changes within the hip. Clinically, they are often difficult to diagnose with nonspecific symptoms, including clicking and anterior groin pain.

Figure 6. (A) T1 coronal fat saturated (FS), demonstrating an extensive tear of the left acetabular labrum superiorly (arrow). (B) Coronal fast spin T1 inversion recovery (FSTIR) in a different patient, demonstrating a paralabral cyst (arrow) secondary to and underlying a right hip labral tear. (C) Fast spin echo (FSE) T2 FS, demonstrating a cam-type femoral acetabular impingement with a pistol grip deformity of the femoral neck (arrow), a small foci of bone marrow oedema at the lateral femoral head (arrowhead), and a tear of the anterior superior labrum.

In the case of internal derangement of the hips, MR arthrography is the examination of choice that distends the capsule, thereby better outlining the labrum and associated abnormalities. Findings of an abnormal labrum include high signal in or through the labrum, a deformed contour of the labrum, or detachment from the acetabulum. Paralabral cysts are a secondary sign of a labral tear and can be useful in indicating the presence of a labral tear in nonarthrograpnic MR examinations [16]. Abnormal head and neck junction morphology, such as in femoroacetabular impingement (cam type), is important to recognize because surgical intervention may prevent further impingement thus preserving the labrum. In our experience, pubalgia and groin pain from femoroacetabular impingement can easily be confused clinically.

Other Injuries

Adductor dysfunction, osteitis pubis, and prehernia complex represent the most common causes of groin pain [3]. One study showed that 57.5% of patients presenting with primary clinical entities of groin pain had pathology secondary to adductor muscle–related pain, whereas 35.3% of cases were secondary to iliopsoas pain and 1.4% because of sports hernia [17]. However, the differential is large, and

Table 1
Causes of athletic groin pain [1,2]

	Pubic	Nonpubic
Musculotendinous	Adductor tendinopathy Inguinal canal pathology Conjoint tendinopathy	Iliopsoas tendinopathy Rectus femoris tendinopathy Various muscle strains (ie, sartorius, gracilis, obturator, externus, tensor fascia lata, gluteus medius)
	Rectus abdominus tendinopathy	
Bone	Osteitis pubis Apophysitis	Pelvic stress fractures
Joint	Pubic instability	Hip joint pathology Lumbar spine pathology Sacroiliac joint pathology
Nerve entrapment	Ilioinguinal nerve Obturator nerve	

Table 2
Causes of nonathletic groin pain [1,2,6]

Genitourinary	Prostatitis, epididymitis, salpingitis, endometriosis, uterine fibroids and/or masses, UTI, lymphadenitis
Intra-abdominal disorders	Aneurysm, appendicitis, diverticulosis, IBD

UTI = urinary tract infection; IBD = inflammatory bowel disease.

other etiologies need to be considered in the appropriate clinical context (Table 1). It is imperative to remember to rule out abdominal and genitourinary nonathletic groin pain that may mimic athletic pubalgia (Table 2).

Treatment

Once a correct diagnosis is made, treatment can be tailored towards its specific pathology. Management of groin pain is designed to strengthen, stabilize, and restore balance to the abdominal wall and pelvic muscles. First-line management includes strengthening and stretching exercises, physiotherapy, deep-tissue massage, anti-inflammatory analgesics, local analgesics, and corticosteroid injections. Patients who fail nonoperative therapy benefit most from surgical interventions. Several operative approaches have been proposed, depending on the exact etiology of the pain. These include diverse methods of hernia repair, including tenotomies of muscle tendons near the pubic bone and release or transection of nearby nerves [18]. Many studies report a success rate of 63%–90% with surgical intervention [18]. Those with adductor tendonitis caused by pelvic instability and weakness of the inguinal wall benefit from endoscopic reinforcement of the wall by using a mesh and possibly staggered tenotomies to complete transection of the adductor longus tendon [18].

Conclusion

Hockey is a fast and aggressive sport, with player mechanics that predispose players to groin injury. Athletic pubalgia and/or groin pain has a large differential diagnosis that is often difficult to differentiate clinically. MRI can play an important role in elucidating the etiology of groin pain and allow prompt and appropriate treatment. Familiarity with the appearance of these injuries in professionals can be applied to the diagnosis of groin pain in amateur athletes.

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